

1 CLAIMS

2  
3 1. One or more computer-readable media having stored thereon a  
4 plurality of instructions that, when executed by one or more processors of a  
5 computer, causes the one or more processors to perform acts including:

6 receiving an image;

7 searching one or more areas of the image for red pixels;

8 combining red pixels together into one or more groups, with adjacent red  
9 pixels being combined into the same group;

10 filtering the groups based on a set of rules, resulting in zero or more  
11 candidate red-eye regions; and

12 classifying each of the candidate red-eye regions as being either part of an  
13 eye or not part of an eye.

14  
15 2. One or more computer-readable media as recited in claim 1, wherein  
16 the searching comprises searching all areas of the image.

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18 3. One or more computer-readable media as recited in claim 1, wherein  
19 the searching comprises searching only within areas of the image that are  
20 identified as including skin color.

21  
22 4. One or more computer-readable media as recited in claim 1, wherein  
23 the red pixels are pixels having the same color as red-eye.  
24  
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1           5.     One or more computer-readable media as recited in claim 1, wherein  
2 the classifying comprises using an SVM (Support Vector Machine) classifier to  
3 classify each of the candidate red-eye regions.

4  
5           6.     One or more computer-readable media as recited in claim 1, wherein  
6 the classifying comprises:

7                 applying a window to the image;

8                 comparing pixels within the window to an eye template;

9                 subsequently altering the scale of the image; and

10                repeating both the applying and the comparing to the scale-altered image.

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12           7.     One or more computer-readable media as recited in claim 1, wherein  
13 the repeating comprises repeating the applying and comparing without altering the  
14 size of the eye template.

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16           8.     One or more computer-readable media as recited in claim 1, wherein  
17 the combining comprises combining candidate pixels into the same group if the  
18 candidate pixels are adjacent one another.

19  
20           9.     One or more computer-readable media as recited in claim 1, wherein  
21 the combining comprises combining candidate pixels into the same group if the  
22 candidate pixels are within a threshold difference of one another.  
23  
24  
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1           **10.**    One or more computer-readable media as recited in claim 1, wherein  
2 one rule of the set of rules is: if greater than a threshold amount of pixels in the  
3 image are the particular one or more colors then none of the pixel groups are  
4 candidate red-eye regions.

5  
6           **11.**    One or more computer-readable media as recited in claim 1, wherein  
7 one rule of the set of rules is: if the group is a single pixel then the group is not a  
8 candidate red-eye region.

9  
10          **12.**    One or more computer-readable media as recited in claim 1, wherein  
11 one rule of the set of rules is: if the group is more rectangular than circular then  
12 the group is not a candidate red-eye region.

13  
14          **13.**    One or more computer-readable media as recited in claim 1, wherein  
15 one rule of the set of rules is: if the group has an aspect ratio substantially  
16 different from a circle then the group is not a candidate red-eye region.

17  
18          **14.**    One or more computer-readable media as recited in claim 1, further  
19 comprising:

20           checking whether a flash was used when capturing the image; and  
21           performing the searching, combining, filtering, and classifying only if a  
22 flash was used when capturing the image.

1 15. A system comprising:

2 a region detection module to detect regions of an image that include pixels  
3 of a particular one or more colors; and

4 an eye confirmation module to receive the detected regions from the region  
5 detection module and identify, for each of the detected regions, whether the  
6 detected region is part of an eye.

7  
8 16. A system as recited in claim 15, wherein the particular one or more  
9 colors are different shades of the same color.

10  
11 17. A system as recited in claim 15, wherein the particular one or more  
12 colors are one or more shades of red.

13  
14 18. A system as recited in claim 15, wherein the image is a digital  
15 image.

16  
17 19. A system as recited in claim 15, wherein the image is a digitized  
18 version of a film image.

19  
20 20. A system as recited in claim 15, wherein the eye confirmation  
21 module is to determine, for each of the detected regions, whether the detected  
22 region is part of a human eye.

1 21. A system as recited in claim 15, wherein the system is implemented  
2 in a computer.

3  
4 22. A system as recited in claim 15, wherein the system is implemented  
5 in a camera.

6  
7 23. A system as recited in claim 15, wherein the system is implemented  
8 in an image printing device.

9  
10 24. A system as recited in claim 15, further comprising:  
11 a skin color module to detect areas of skin color in the image and indicate  
12 the detected areas to the region detection module; and  
13 wherein the region detection module is to search within the detected areas  
14 to detect regions that include pixels of the particular one or more colors.

15  
16 25. A system as recited in claim 15, wherein the eye confirmation  
17 module comprises an SVM (Support Vector Machine) classifier to classify each of  
18 the detected regions as either part of an eye or not part of an eye.

19  
20 26. A system as recited in claim 15, wherein the eye confirmation  
21 module comprises a multi-scale classifier to apply a window to the image and  
22 compare pixels within the window to an eye template, to alter the scale of the  
23 image, and then to repeat the application of the window to the scale-altered image  
24 and comparison to the eye template.  
25

1     ~~27. A system as recited in claim 15, wherein the region detection~~  
2 module comprises a pixel identifier that is trained to colors associated with red-  
3 eye, and wherein the pixel identifier is to identify pixels within the region having  
4 colors that are close to the colors associated with red-eye.

5  
6     28. A system as recited in claim 27, wherein the region detection  
7 module further comprises a pixel grouper coupled to receive the identified pixels  
8 from the pixel identifier and group together adjacent pixels.

9  
10     29. A system as recited in claim 28, wherein the pixel grouper is further  
11 to group together pixels within a threshold distance of one another.

12  
13     30. A system as recited in claim 28, wherein the region detection  
14 module further comprises a filter to receive an indication of the groups of pixels  
15 from the pixel grouper and to identify, based on a set of rules, which of the groups  
16 are to be output to the eye confirmation module as detected regions:

17  
18     31. A system as recited in claim 30, wherein one of the rules is: if  
19 greater than a threshold amount of pixels in the image are the particular one or  
20 more colors then none of the pixel groups are detected regions.

21  
22     32. A system as recited in claim 30, wherein one of the rules is: if the  
23 group is a single pixel then the group is not a detected region.

1 ~~33. A system as recited in claim 30, wherein one of the rules is: if the~~  
2 group is more rectangular than circular then the group is not a detected region.

3  
4 34. A system as recited in claim 30, wherein one of the rules is: if the  
5 group has an aspect ratio substantially different from a circle then the group is not  
6 a detected region.

7  
8 35. A method comprising:  
9 receiving an image;  
10 searching a set of areas of the image for candidate pixels of one or more  
11 colors;  
12 combining the candidate pixels into a set of one or more pixel groups; and  
13 for each pixel group in the set of one or more pixel groups, classifying the  
14 pixel group as being part of an eye or not part of an eye.

15  
16 36. A method as recited in claim 35, wherein the one or more colors  
17 comprise colors corresponding to red-eye.

18  
19 37. A method as recited in claim 35, wherein the receiving comprises  
20 receiving the image from a camera.

21  
22 38. A method as recited in claim 35, wherein the one or more colors  
23 comprises one or more shades of red.  
24  
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1        ~~39. A method as recited in claim 35, further comprising:~~

2        identifying areas within the image that are skin colored; and  
3        using the identified areas as the set of areas.

4  
5        40. A method as recited in claim 35, wherein the combining comprises  
6        combining two candidate pixels into the same pixel group if the two candidate  
7        pixels are within a threshold distance of each other.

8  
9        41. A method as recited in claim 35, further comprising for each pixel  
10       group in the set of one or more pixel groups, prior to classifying the pixel group:

11       identifying the geometric shape of the pixel group;

12       determining whether the geometric shape is similar to the shape of an eye;

13       and

14       leaving the pixel group as part of the set of one or more pixel groups if the  
15       geometric shape is similar to the shape of an eye, and otherwise removing the  
16       pixel group from the set.

17  
18       42. A method as recited in claim 41, wherein the shape is similar to the  
19       shape of an eye if the geometric shape is more circular than rectangular and if an  
20       aspect ratio of the geometric shape differs from the aspect ratio of a circle by not  
21       greater than a particular amount.

22  
23       43. A method as recited in claim 35, wherein the classifying comprises:  
24       applying a window to the image and comparing pixels within the window  
25       to an eye template;



1 ~~altering the scale of the image; and~~  
2 repeating the applying and comparing based on the scale-altered image.

3  
4 44. A method as recited in claim 43, wherein the repeating comprises  
5 repeating the applying and comparing based on the scale-altered image without  
6 altering the size of the eye template.

7  
8 45. A method as recited in claim 35, wherein the combining comprises  
9 combining candidate pixels into the same group if the candidate pixels are  
10 adjacent one another.

11  
12 46. A method as recited in claim 35, further comprising removing,  
13 based on a set of rules, groups from the set of one or more pixel groups.

14  
15 47. A method as recited in claim 35, further comprising:  
16 checking whether flash was used in capturing the image; and  
17 performing the searching, combining, and classifying only if flash was used  
18 in capturing the image.

19  
20 48. A method as recited in claim 47, wherein checking whether flash  
21 was used in capturing the image comprises checking whether a flash used flag is  
22 set in a header corresponding to the image.

1 ~~49. One or more computer-readable memories containing a computer~~  
2 program that is executable by a processor to perform the method recited in claim  
3 35.

4  
5 **50.** A camera comprising:

6 an image capturer to capture an image; and

7 a red-eye detector including,

8 a region detector to detect regions of the image that include red  
9 pixels, and

10 an eye confirmer to receive the detected regions from the region  
11 detector and identify, for each of the detected regions, whether the detected  
12 region is an eye.

13  
14 **51.** A camera as recited in claim 50, wherein the image capturer  
15 comprises film.

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17 **52.** A camera as recited in claim 50, wherein the image capturer  
18 comprises a charge coupled device (CCD).

19  
20 **53.** A system comprising:  
21 means for searching a set of areas of an image for candidate pixels of one  
22 or more colors;  
23 means for combining the candidate pixels into a set of one or more pixel  
24 groups; and  
25

1 ~~means for classifying, for each pixel group in the set of one or more pixel~~  
2 ~~groups, the pixel group as being part of an eye or not part of an eye.~~

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4 54. A system as recited in claim 53, further comprising means for  
5 removing a group from the one or more pixel groups based on a set of rules.  
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